National Park Service
U.S. Department of the Interior

Crater Lake National Park

Whitebark Pine Conservation Program

2018 Annual Report

ON THIS PAGE
Healthy whitebark pines growing along the caldera edge.
Photo by Jen Hooke.

ON THE COVER
Wind-sculpted whitebark pine growing near the top of Mt. Scott.
Photo by Jen Hooke.

Whitebark Pine Conservation Program

2018 Annual Report

Jennifer S. Hooke

National Park Service
Crater Lake National Park
P.O. Box 7
Crater Lake, Oregon 97604

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U.S. Department of the Interior
National Park Service
Crater Lake National Park
Crater Lake, Oregon

The Natural Resource Data Series is intended for the timely release of basic data sets and data summaries. Care has been taken to assure accuracy of raw data values, but a thorough analysis and interpretation of the data has not been completed. Consequently, the initial analyses of data in this report are provisional and subject to change.

All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner.

This report received informal peer review by a subject matter expert who was not directly involved in the collection, analysis, or reporting of the data.

This report is available in digital format from the Crater Lake National Park website at: https://irma.nps.gov/DataStore/Reference/Profile/2259925

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Abstract

Major activities of Crater Lake National Park's Whitebark Pine Conservation Program in 2018 supported the Park's goals and objectives for conserving and restoring whitebark pine. Cones were collected from three new whitebark pine trees and sent to the Dorena Genetic Resource Center for blister rust resistance screening. Sixty-four trees were subject to annual Collection tree monitoring efforts. This monitoring detected no new mortality of Collection trees, no new blister rust infections, and no new mountain pine beetle attacks. Fifty-one whitebark pines of management importance were treated with verbenone to help ward off attack by the mountain pine beetle. Results from the Park's long-term monitoring plots indicate that whitebark pine is continuing its decline within plot areas, as mature whitebark pine have been reduced by 28.3% from 2003—2018. The leading mortality agents of whitebark pine within plot areas are white pine blister rust and mountain pine beetle. The Park's six whitebark pine restoration plantings were monitored with survival rates ranging from 62.1%--85.2% two to nine years after planting.

Acknowledgments

The Crater Lake National Park Whitebark Pine Conservation Program received funding assistance from the United States Forest Service Forest Health Protection program enabling verbenone application to management trees of importance (e.g., rust-resistant and large-diameter trees). Special thanks go to Rob Flowers for delivering verbenone to the Park. The USFS Dorena Genetic Resource Center continued to assist the Park with blister rust resistance screening and monitoring the Park’s six whitebark pine restoration plantings. Bob Danchok and Emily Boes of the Dorena Genetic Resource Center caged and collected whitebark pine cones. Tara Chizinski, Hamilton Hasty, Scott Heisler, Thomas Hender, Alissa Iverson, Delacey Randall, Kaylin Scott, and Carrie Wyler assisted with sampling the Park’s long-term whitebark pine monitoring plots.

Introduction

Whitebark pine (*Pinus albicaulis* Engelm.) is a hardy, long-lived species that tolerates the harsh conditions found at the highest elevations of Crater Lake National Park (CRLA). Whitebark pine is considered both a foundation and a keystone species due to the important role it plays in creating and sustaining high elevation vegetation communities (Tomback et al. 2014). The seedlings of whitebark pine can tolerate full sun and are able to establish in previously tree-less areas, earning it the reputation of a colonizing or pioneer species (Tomback et al. 2001 – Figure 1). Once established, they ameliorate harsh site conditions and facilitate the establishment of a diverse suite of subalpine species. Whitebark pine stands serve important functional roles such as shading and retaining snowpack and thereby regulating snowmelt, and slowing erosion by anchoring soils in place. Whitebark pine shares a mutualistic, co-evolved relationship with the Clark's nutcracker (*Nucifraga columbiana*). Whitebark pine is considered a "stone pine" as it bears cones that remain closed at maturity and require animal assistance (typically from Clark's nutcrackers – but also from squirrels, bears, and other mammals) to open cones and extract seeds. The Clark's nutcracker stores whitebark pine seeds in "caches" for future use, relying on a complex spatial memory to enable it to retrieve seeds at a later date. Caches that are not utilized can develop into whitebark pine stands and woodlands.

Figure 1. A whitebark pine seedling grows in a rock crevice along the caldera rim. Photo by Jen Hooke.

Whitebark pine has been declining within the Park for decades. A non-native pathogen, *Cronartium ribicola*, which causes the disease white pine blister rust (WPBR), was introduced to western North America in 1910. Since that introduction, WPBR has spread throughout the range of whitebark pine with devastating results. Few whitebark pines have genetic resistance to WPBR, and the disease is progressive and fatal. Warming temperatures and milder winters at high elevations have facilitated a prolonged outbreak of the native mountain pine beetle (MPB – *Dendroctonus ponderosae*). At CRLA, MPB is one of the leading mortality agents for whitebark pine (Smith et al. 2011), although MPB activity in whitebark pine has waned over the past several years (Smith 2017, Smith 2018). Projected suitable habitat for whitebark pine under different climate change scenarios declines steeply, especially in the Cascade Range (Warwell et al. 2007; Littell et al. 2013). In 2011, the United States Fish and Wildlife Service determined that listing whitebark pine as a threatened or endangered species was warranted but precluded by higher priority work. Whitebark pine remains a Candidate species for listing under the Endangered Species Act.

In 2003, CRLA applied the first actions in what would become a Whitebark Pine Conservation Program (WPCP). The Terrestrial Ecology team began by implementing a whitebark pine long-term monitoring program and collecting cones from whitebark pines so that seedlings could be grown and tested for resistance to WPBR at the United States Forest Service (USFS) Dorena Genetic Resource Center (DGRC – Figure 2). Since then, CRLA's WPCP has expanded to include not only long-term monitoring and rust-resistance screening, but outplanting seedlings grown from rust-resistant "Parent" trees for restoration; applying verbenone, a bark beetle repellent, to large-diameter "legacy" whitebark pines and those that have had their cones collected for rust-resistance screening (called "Collection Trees"); and annual monitoring of rust-resistant trees. This report summarizes major activities of the WPCP in 2018 including: (1) cone collection; (2) Collection tree monitoring, (3) verbenone application; (4) CRLA's long-term whitebark pine monitoring, and (5) whitebark pine restoration plantings.

Figure 2. Whitebark pine seedlings for restoration grown at the DGRC sourced from CRLA trees. Photo by Jen Hooke.

Since many aspects of whitebark pine biology and health (e.g., seedling mortality and survival; tree vigor; length of growing season) are affected by annual climactic trends, it is important to note that the Park and the region returned to drought conditions in 2018. The Park received 336" of snow at Park headquarters (average is 512") during the 2017—2018 water year (October 1 – September 30), which is 65.7% of average. The total amount of precipitation (melted) received at Park headquarters was 54" (average is 65"), which is 83% of average. Snowmelt occurred early in spring 2018, with the first snow-free date at Park headquarters reached on May 28th (average date is June 18th).

Methods

Methods are discussed separately for each of the five major components of the 2018 WPCP.

Cone Collection

All CRLA whitebark pines that have had cones collected and sent to the DGRC for rust-resistance screening are called "Collection" trees. To collect cones from whitebark pine, cages (Figure 3) are installed around developing cones early in the summer to protect seeds from wildlife species such as the Clark's nutcracker. In fall, cages are removed, and cones harvested and sent to the DGRC to be used in rust resistance screening trials and/or to provide seedlings for restoration outplantings. While cones can be reached from the ground by hand, using a cone hook, or by using an orchard ladder, most trees need to be climbed to facilitate cone collection. The Park follows cone collection guidelines outlined in Ward et al. (2006). This includes selecting whitebark pines from areas with moderate to high WPBR infection levels; selecting trees that are safe to climb; selecting trees that appear free of disease, of good vigor, and with sufficient cones (although trees infected with WPBR are occasionally collected for use as "controls" in the rust resistance screening process); and collecting cones from only one bole in a cluster of whitebark pine stems.

Figure 3. Installing cages around cones to protect developing seeds from predation prior to harvest. Photo by Jen Hooke.

Collection Tree Monitoring

The DGRC has been assessing which CRLA whitebark pines have some level of resistance to WPBR since 2003. The rust-resistance screening process currently takes seven years to complete; two-year-old seedlings are inoculated with *C. ribicola* at the DGRC, monitored for five years, and then assigned a resistance rating of A-F (much like grades in school) with "A" showing the most resistance and "F" the least. Collection trees are given a rating of A-F based on the rust-resistance of their progeny. Trees that receive A-C rust-resistance ratings are deemed "Resistant" trees. Trees that receive "D" and "F" ratings are "Susceptible" trees; and trees whose progeny are currently undergoing rust-resistance screening trials are called "Candidate" trees. While the most rust-resistant trees are considered "A" and "B" trees, "C" trees are considered moderately resistant and included in the definition of Resistant trees to include more genetic diversity for restoration purposes. All Resistant and Candidate trees are monitored on an annual basis.

Annual Collection Tree Monitoring entails assessment for WPBR, MPB, dwarf mistletoe, or other damage; assessing the cone crop; and photographing the tree and any notable features (e.g., cankers).

Parameters such as diameter at breast height (DBH), tree height, assessment of non-whitebark pine conifer competitors, and spatial coordinates are updated every five years. A complete account of the Collection Tree Monitoring program is available in the Crater Lake National Park Whitebark Pine Conservation Plan (Beck and Holm 2014). Typically verbenone application to Resistant and Candidate trees occurs concurrently with Collection Tree Monitoring.

Verbenone Application

The MPB utilizes a group attack strategy to kill a host tree. When a female beetle finds a suitable host, she emits an aggregating pheromone that invites other beetles to colonize the host. Conversely, when the host tree has been fully colonized, beetles produce an anti-aggregating pheromone to signal to other beetles that the host is fully occupied. Verbenone is a synthetic form of the anti-aggregating pheromone, and it has been applied as a bark beetle repellent to high-value whitebark pines at CRLA since 2004. Both pouch and SPLAT verbenone formulations were used at CRLA in 2016 and 2017. Pouch formulations have verbenone encased in plastic wrappers that are stapled to tree bark; the SPLAT formulation is a thick gel-like substance that is applied to tree boles via a caulking gun. The Park used only the pouch formulation of verbenone in 2018, as the SPLAT formulation was deemed inappropriate for use at CRLA since it was found to persist on tree boles and leave an oily stain on tree bark (Figure 4). To apply verbenone pouches to a tree, two 7g pouches are stapled to the north side of the bole as high up as the applicator can reach while spacing the pouches at least one vertical foot apart. Trees with DBH > 100 cm often have four verbenone pouches attached when supplies allow. Verbenone is applied annually in June or July to all living Resistant and Candidate trees with the exception of trees with < 15 cm DBH. Pouches remain attached until the following June, when they are removed and replaced with fresh pouches.

Figure 4. SPLAT verbenone did not biodegrade after two growing seasons. Photo by Jen Hooke.

Since many Collection trees are found in high visitor-use areas (near trails, pullouts, overlooks, etc.), a small laminated note is attached to trees treated with verbenone alerting Park visitors of the treatment purpose and warning them to not touch the verbenone. In years with low verbenone supplies due to budgetary constraints, “C” rated Resistant trees may not be treated. The full CRLA Verbenone Treatment Plan is available in the Park’s Whitebark Pine Conservation Plan (Beck and Holm 2014).

In past years, assistance was received from the Forest Health Protection (FHP) program to treat large-diameter “legacy” whitebark pines with verbenone. Verbenone was applied to these legacy whitebark pines in the areas suffering the highest levels of MPB activity along East Rim Drive from Scott Bluffs to Crater Peak as determined by ocular surveys. Legacy trees were identified by surveying an area impacted by recent MPB activity and seeking out large-diameter trees that appeared to be good cone producers and/or very old based on their diameters. Legacy trees were treated with both SPLAT and pouch verbenone formulations. Verbenone application to legacy whitebark pines did not occur in 2018 due to limited MPB activity, but a final assessment was made of trees treated during the 2017 field season.

Long-Term Whitebark Pine Monitoring

Crater Lake National Park implemented a long-term monitoring program in 2003 to track changes in whitebark pine communities. Seven plots were strategically placed in areas representing different whitebark pine-dominated vegetation types throughout the Park (Figure 5). With the exception of 2008, plots have been sampled annually since 2003. These plots track changes in tree health and density, understory vegetation cover, and substrate cover. Tree data are collected annually (with the exception of data on DBH, tree height, and canopy position, which are collected every five years); understory vegetation data are collected every other year; and substrate cover data are collected every five years. Parameters collected annually on individual trees include tree health, blister rust infection and presence of active and inactive cankers, MPB attack and severity, presence of cones, presence of mammal damage (e.g., gnawing) and severity, and any additional damage (e.g., chlorosis, mechanical damage) that may have affected the tree. Understory vegetation and substrate data are collected using a relevé approach encompassing the entire plot. In 2018, plots were sampled from September 7 – 15.

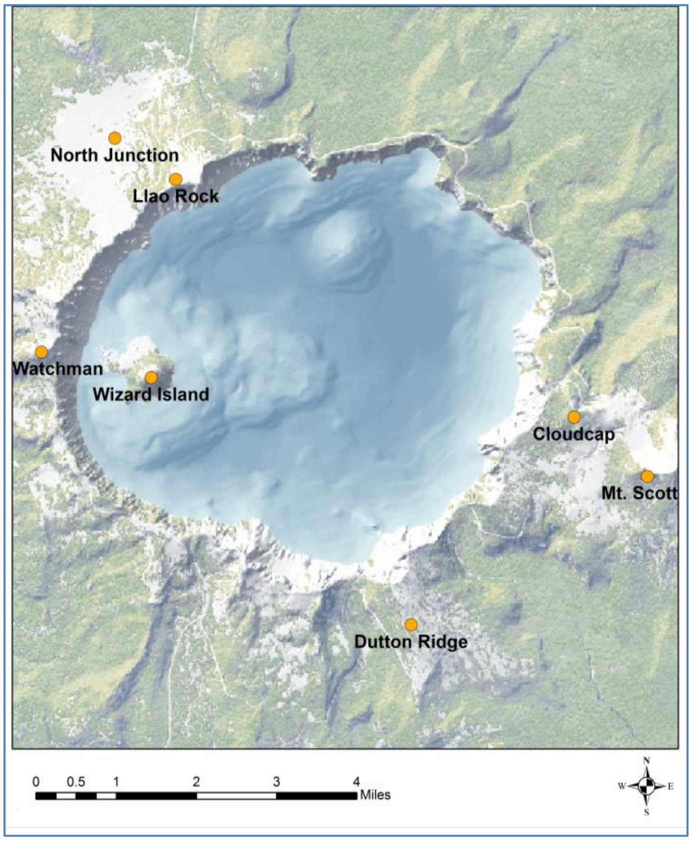

Figure 5. Locations of CRLA's long-term whitebark pine monitoring plots. Map by Jen Hooke.

This Park-based long-term monitoring effort is separate from and complementary to the Vital Sign long-term monitoring of whitebark pine implemented in 2012 by the National Park Service (NPS) Klamath Inventory and Monitoring Network (KLMN). The KLMN effort established 30 whitebark pine long-term monitoring plots throughout the Park utilizing a peer-reviewed protocol employed by several NPS units in the Pacific West region. Information on this effort is available here: https://www.nps.gov/im/klmn/whitebark.htm

Whitebark Pine Restoration Plantings

Six whitebark pine restoration plantings have occurred at CRLA: the Rim Village, Horse Trail, Dutton, North Junction, Grouse Hill, and Scott Bluffs plantings (Figure 6). Each planting utilized three-year-old seedlings from CRLA Parent trees grown by the DGRC. Seedlings are monumented with small metal tags inserted at ground level and mapped to ease relocation using a sub-meter accuracy Trimble GPS unit and ArcMap software. Seedlings are monitored annually for WPBR infection, vigor, growth, and damage as a joint effort between CRLA and the DGRC.

The 2009 Rim Village planting utilized an opportunity to restore the site of a former parking lot between the Rim Village Café and Gifts building and the Rim Village promenade. Three hundred and thirty-two seedlings were planted from 17 Resistant and Susceptible CRLA Parent trees. Susceptible seedlings were included in the restoration planting as a field validation of rust-resistance results determined by the DGRC. Since the planting site was a former parking lot, soils were highly compacted and a backhoe and auger were used to drill planting holes. Boulders, woody debris, and forest litter and duff were added to ameliorate the harshness of the planting site. Between one and three seedlings were placed in a planting hole. Seedlings were planted from September 15 – 23, 2009, and watered as needed until snowfall on October 1.

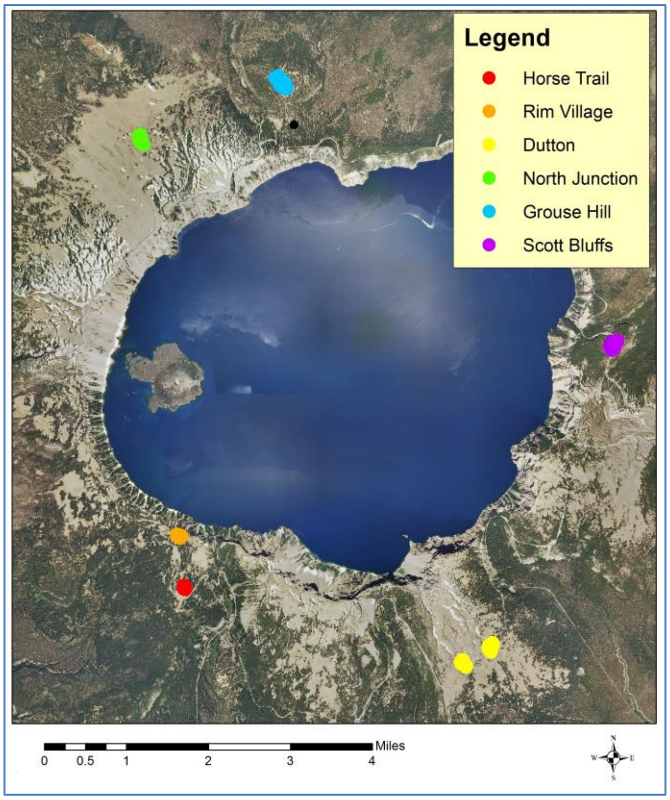

Figure 6. Locations of CRLA's six whitebark pine restoration outplantings. Map by Jen Hooke.

The 2009 Horse Trail planting, located just south of Rim Village, is both a restoration project and an experiment to determine if inoculating seedlings with a beneficial fungal endophyte increases their chance of survival. Endophytes are fungal species that live inside plants and may confer benefits to their host such as resisting infection from WPBR. One hundred ninety-two seedlings were planted at the Horse Trail site from five Resistant and Susceptible CRLA Parent trees. One half of the seedlings were inoculated with the endophyte *Myrothecium roridum*, the other half were treated with distilled water as controls. Seedlings were randomized and planted in five circular "family" (i.e., from the same Parent tree) plots; seedlings were planted one or two to a planting hole and seedlings with differing treatments were not planted in the same planting hole. No ameliorations were made to the site prior to planting. Seedlings were planted on September 28, 2009, and watered immediately after planting. It was never confirmed if the inoculation of whitebark pine seedlings with *M. roridum* was successful; however this may be determined in the future.

The 2012 Dutton Ridge and North Junction plantings were part of a FHP funded project involving CRLA, DGRC, the Deschutes National Forest, and Oregon State University. A total of 416 seedlings were planted at both sites. Seedlings originated from ten CRLA Parent trees; eight of these Parent trees were Resistant and two were Susceptible. The rationale for including Susceptible trees in the restoration planting is again to field-validate rust-resistance results determined by the DGRC. This project incorporated a randomized block design with the number of seedlings from each Parent tree divided as equally as possible among the blocks. Due to more area available for planting at Dutton Ridge vs. North Junction, five blocks were placed at Dutton Ridge with three blocks at North Junction. Fifty-two seedlings were assigned to each block. Seedlings were planted one to a planting hole, and planting hole locations were determined based on proximity to naturally occurring ameliorating microsite features such as downed wood and rocks (Figure 7). Seedlings were planted on October 18, 2012, and received no watering. Immediately after planting, the Park experienced a series of storms and received 27" of snow from October 19 – 25, 2012. In 2013, 130 naturally occurring whitebark pine seedlings of similar size to planted whitebark pine seedlings at the Dutton Ridge and North Junction sites were tagged, mapped, and assessed for height, vigor, WPBR infection, and damage. These "natural regeneration" seedlings are included in the annual monitoring of this restoration project.

Figure 7. Whitebark pine seedling planted next to ameliorating downed wood to increase probability of survival. Photo by Jen Hooke.

Two new restoration plantings occurred in 2016 at Grouse Hill and Scott Bluffs. These sites were selected based on having high levels of overstory whitebark pine mortality and little natural regeneration. A total of 484 seedlings were planted at both sites. Seedlings originated from sixteen CRLA Parent trees; fourteen of these Parent trees were Resistant and two were Susceptible. The rationale for including Susceptible trees in the restoration planting is again to field-validate rust-resistance results determined by the DGRC. This project incorporated a randomized block design with the number of seedlings from each Parent tree divided as equally as possible among the blocks. Four blocks were placed at Grouse Hill with four blocks at Scott Bluffs. The number of seedlings assigned to each block ranged from 59-61. Seedlings were planted one to a planting hole, and planting hole locations were determined based on proximity to naturally occurring ameliorating microsite features such as downed wood and rocks. Seedlings were planted on October 11-12th and received no watering. Immediately after planting, the Park experienced a series of storms and the planting sites were covered by over a foot of snow.

Results

Results are presented separately for each component of 2018 WPCP activities.

Cone Collection

Whitebark pine cone production during the 2018 season was low, with some whitebark pine habitats offering a light cone crop and others devoid of cones. Whitebark pine produces an irregular cone crop, with poor years, moderate years, and strong or mast years occurring at unpredictable intervals (Ward et al. 2006). It is thought that this is the tree's strategy to outwit cone predators such as cone weevils by producing an unreliable food source (Lanner 1996). The Park has experienced several consecutive low- to moderate-production cone years recently; the last mast year was in 2009.

No cone collection was planned for the 2018 field season due to a low-production cone year Park-wide. However, when the DGRC staff came to CRLA in July to monitor the Park's six whitebark pine restoration plantings, three trees were found with cones that could be caged and collected from the ground. These trees were located closely together in the North Junction area. Cone cages were installed on June 19 and removed at cone harvest on September 27, 2018.

Few conelets (Figure 8) were observed in the fall of 2018, so no plans are presently in place to collect cones during the 2019 season.

Figure 8. First-year whitebark pine cone or "conelet." Photo by Jen Hooke.

Collection Tree Monitoring

The Park has a total of 126 Collection trees, which are trees from which cones have been collected for rust resistance screening since 2003. Sixty-four Collection trees were monitored in 2018, which encompasses all living Resistant and Candidate trees. No Collection trees died in 2018; the last time Collection trees perished was in 2015. Twelve Collection trees have died since the start of this project; six were Resistant and six were Susceptible trees. The Park has lost 6 of its 39 Resistant trees (15.4%), 5 due to MPB and 1 to WPBR (Figure 9). Six out of 59 Susceptible trees (10.2%) have died; 3 from MPB, 1 from WPBR, and 2 from unknown causes (Figure 9). Rust-resistance screening results have been received from 98 Collection trees to date; preliminary results should be available soon for 2014 Collection trees (n = 13). Twenty-eight trees are "Candidate" trees, which means their blister rust resistance ratings are pending. Rust resistance at CRLA is promising so far with 40% of tested trees (n=98) showing some degree of resistance (Figure 9), although sample sizes are small and more results will contribute to a better understanding of resistance and how it differs across CRLA whitebark pine habitat.

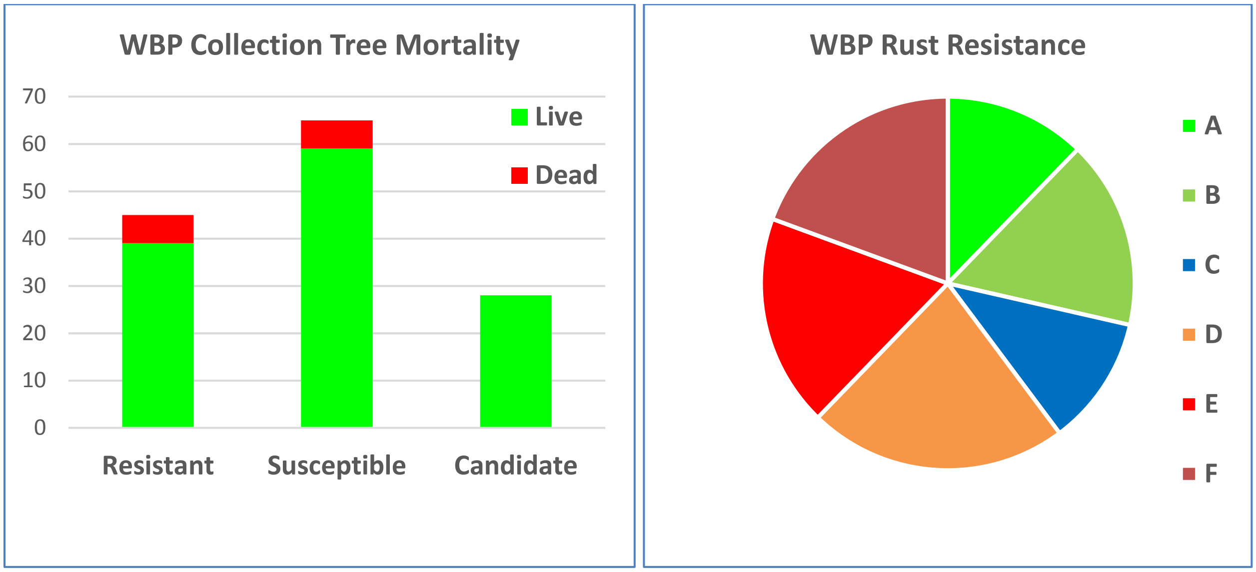

Figure 9. Collection tree mortality (left) and rust-resistance status for CRLA's whitebark pine (right).

Eleven Collection trees initially selected for their phenotypic resistance to WPBR have since displayed disease symptoms; these trees are BC03 (Candidate tree); CL02 ("B" tree); CL03 (A" tree); DR03 ("D" tree); GC06 (Candidate tree); RV01 ("D" tree); RV02 ("D" tree); RV03 ("C" tree); RV07 ("F" tree); RV09 ("D" tree); and WM04 ("E" tree). Three trees (GC02 – "F" tree; MS03 – "E" tree; SK05 – "E" tree) that were observed to have WPBR infections in 2011 have not manifested symptoms since but they continue to be monitored. Three trees infected with WPBR and selected as controls for the rust-resistance screening process continue to display disease symptoms: CC10, CC12, and GC05. No new MPB attacks were observed on any of the 64 Collection trees monitored during the 2018 season.

Verbenone Application

Verbenone (Figure 10) was applied to 51 Resistant and Candidate trees (including two Susceptible trees – CL23 and CW02 – due to their good health and legacy tree status) from June 5—27. All trees had two pouches applied except for large-diameter trees NJ01 and NJ02, which had four pouches attached. No monitored Collection trees succumbed to MPB attack this year, and all trees that had verbenone applied in 2017 appeared unaffected by MPB in 2018.

The MPB outbreak that has been impacting CRLA's whitebark pine since at least 2003 has subsided. Occasional MPB attacks still cause WBP mortality, but the severity of attacks has decreased. While the annual MPB-caused mortality of whitebark pine is concerning, the cumulative impacts of over a decade of MPB attack have been devastating to the Park's whitebark pine communities. In an attempt to protect the Park's old, large-diameter whitebark pines from MPB-caused mortality, additional verbenone was obtained from the USFS FHP program. This allowed for the treatment of

123 “legacy” whitebark pines with verbenone in areas throughout the Park suffering the highest MPB activity throughout 2015—2017.

Figure 10. Applying verbenone to a rust-resistant whitebark pine on Mt. Scott. Photo by Jen Hooke.

All 135 legacy whitebark pines treated with verbenone in 2017 were assessed in 2018 for their survival and any MPB impacts. Out of these 135 legacy trees, 124 (91.8%) were still alive in 2018; eleven legacy trees were killed by MPB attack later in the 2017 growing season despite verbenone application (Figure 11). Areas that experienced MPB-caused tree mortality were Anderson Meadows, Dutton Ridge, the Mt. Scott Meadows area, and Scott Bluffs. Due to waning MPB activity no legacy verbenone work is planned for the 2019 field season, but conditions will continue to be monitored and the workload adjusted if necessary.

The Park uses Aerial Detection Survey (ADS) data provided by USFS Region 6 (Oregon and Washington) as an estimate of MPB activity on an annual basis (Figure 12). These data are not field-verified, and are used by the Park to detect rough trends in MPB activity. The 2018 ADS data show the MPB continuing to have an impact on forest health, including at the Park’s highest elevations, but the area affected is much smaller than in previous years. The Mt. Scott area is the only whitebark pine habitat affected by MPB appearing in the ADS data in 2018.

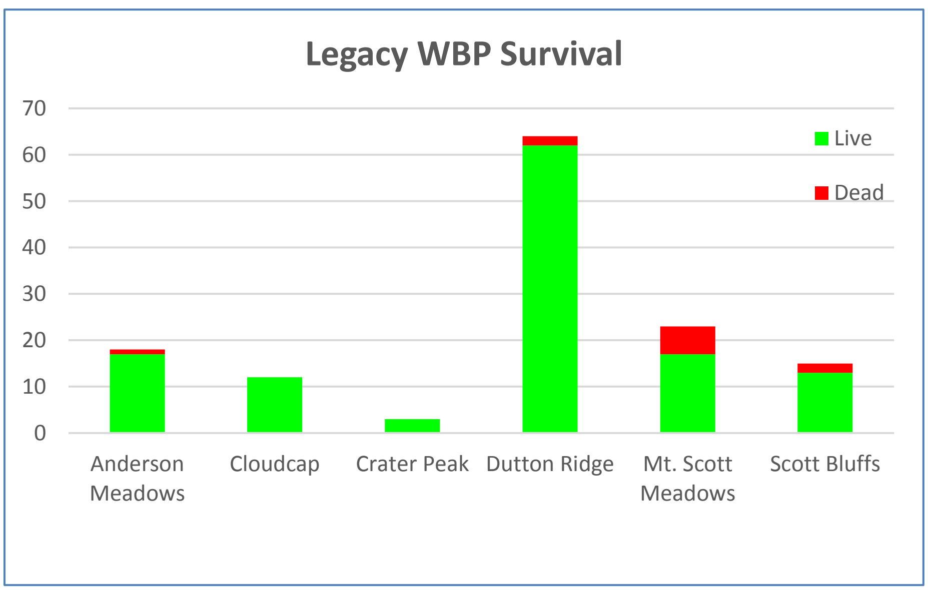

Figure 11. Number of legacy WBP (n = 135) treated with verbenone in 2017 still alive in 2018 (by treatment site).

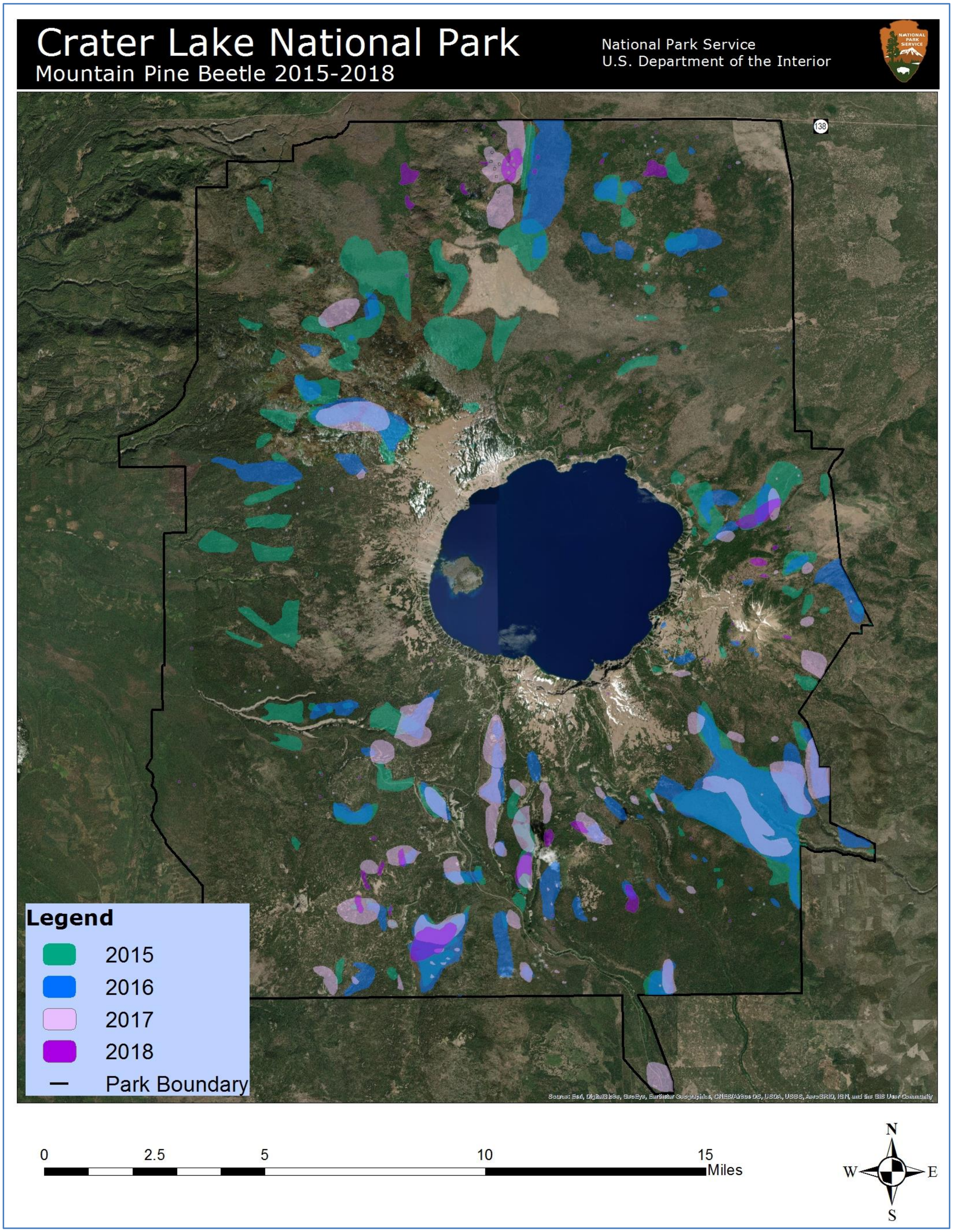

Figure 11. USFS ADS data for MPB activity within CRLA from 2015-2018. Map by Jen Hooke.

Long-Term Whitebark Pine Monitoring

The Park's seven long-term whitebark pine monitoring plots were sampled from September 7 – September 15, 2018. Recent MPB activity was observed at only the Cloudcap plot, where two new trees were heavily attacked. All plots continue to be impacted by WPBR; additionally, the Wizard Island plot continues to be devastated by dwarf mistletoe. Mortality of seedlings within plot areas in 2018 was caused by WPBR, animal predation, mechanical damage, or drought/desiccation.

Overstory whitebark pines (> 15 cm DBH) within plot areas have been reduced by 28.3% from 2003 to 2018; sapling whitebark pines (> 0 and < 15 cm DBH) have remained stable during this period due to recruitment. In 2017—2018, MPB and WPBR have been the primary mortality agents for overstory whitebark pine within plot areas, with MPB-caused mortality resulting from trees finally succumbing to attacks made in previous years. Mean blister rust infection of live whitebark pine has changed from 11.5% in 2003 to 41.7% in 2018. Average blister rust infection in live trees > 15 cm DBH has changed from 12.1% in 2003 to 48.7% in 2018.

These seven plots were subjectively established in relatively pure whitebark pine habitat. In 2003, mountain hemlock (*Tsuga mertensiana*) seedlings were detected in only two (Mt. Scott and Watchman) plots. As of 2018, mountain hemlock seedlings have been detected in all but the Dutton and North Junction plots.

Whitebark Pine Restoration Plantings

The Park's six whitebark pine restoration plantings were monitored from July 16—19 with assistance from the DGRC. The first seed cone was discovered in 2018 on a whitebark pine planted for restoration at Rim Village (Figure 12). This was an exciting development, as cone production was not expected at the 2009 restoration plantings for at least another decade. The Park's six established whitebark pine restoration plantings continued to do relatively well two to nine years after planting. Despite continued issues with visitor trampling, the Rim Village site continues to have the highest survival rate of any of the Park's six restoration planting sites. The 2018 survival rates for planted seedlings range from 62.1% to 85.2% and are displayed in Table 1. Data on survival of natural regeneration are also included in this table, as they provide some information on background mortality rates in naturally occurring whitebark pine seedlings.

Figure 12. The first seed cone developing on one of the Park's whitebark pines planted in 2009 for restoration. Photo by Jen Hooke.

Table 1. Survival rates for the Park's six whitebark pine restoration planting sites as of 2018. Natural whitebark pine regeneration was not monitored at Dutton Ridge and North Junction until 2013.

Site	2009	2010	2011	2012	2013	2014	2015	2016	2018
2009 Horse Trail Planting (n = 192)	100.0	84.4	82.3	79.7	78.1	77.1	73.4	68.2	66.7
2009 Rim Village Planting (n = 332)	100.0	97.0	91.5	91.2	90.9	89.7	87.9	87.3	85.2
2012 Dutton Ridge Planting (n = 260)				100.0	88.8	78.5	73.8	70.0	67.7
2012 North Junction Planting (n = xxx)				100.0	89.1	80.8	73.7	71.8	66.7
Dutton Ridge Natural Regeneration (n = 88)					100.0	91.0	87.6	84.1	84.1
North Junction Natural Regeneration (n = 47)					100.0	95.7	95.7	95.7	95.7
2016 Grouse Hill Planting (n = 240)								100.0	62.1
2016 Scott Bluffs Planting (n = 244)								100.0	78.7

Discussion

The 2018 season marked another year of efforts made by the Park to implement the CRLA Whitebark Pine Conservation Plan. While the Park continued to experience declines in whitebark pine populations due to mortality caused by MPB, WPBR, dwarf mistletoe, and other factors, efforts to conserve the species continued. An interpretive wayside display (Figure 13) highlighting the whitebark pine restoration planting at Rim Village was created with the assistance from Interpretation staff; it will be installed in spring of 2019.

Work for the WPCP in 2019 will retain emphasis on Collection Tree Monitoring and verbenone application to all Resistant and Candidate trees; sampling the Park's seven long-term whitebark pine monitoring plots; and monitoring the Park's six whitebark pine restoration outplantings. While cone collection is not presently planned for 2019, this may change if cone-bearing trees are encountered. If conelets indicate a good cone collection year in 2020, funding will be pursued to enable new cone collections and continue rust-resistance screening in the 2020 season.

Recommendations for WPCP work in the 2019 season include:

- Seek funding to procure 2020 verbenone as opportunities arise.
- Continue to collaborate with the DGRC on monitoring health and status of whitebark pine restoration outplantings.

- Start planning for whitebark pine release treatments around rust-resistant trees and in areas with high probability of rust-resistance that are being threatened by non-whitebark pine conifer competition.

- Identify opportunities for fuels treatments in whitebark pine habitat in conjunction with Fire Management staff.

- Work with the Rim Village Visitor Center planning team to ensure that whitebark pines are protected during construction and considered during revegetation efforts.

- Identify new areas for potential whitebark pine restoration plantings.

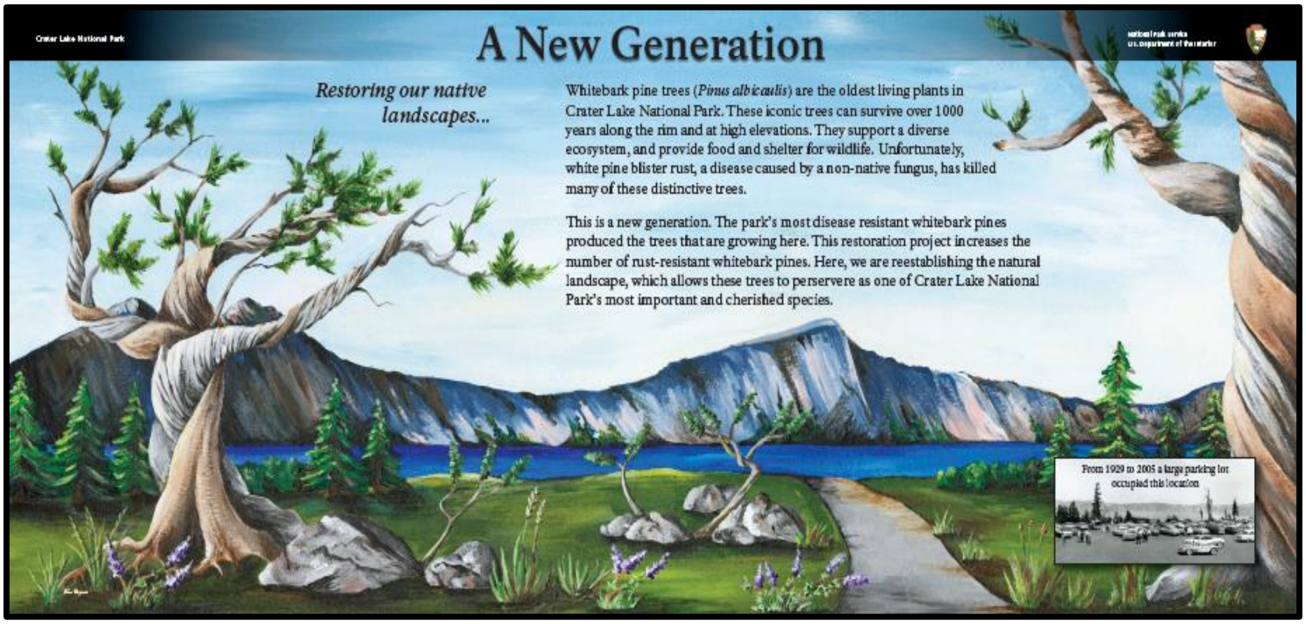

Figure 13. A new interpretive wayside to be installed at the Rim Village whitebark pine restoration planting site in spring of 2019. Original artwork by Tara Chizinski.

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Crater Lake National Park
P.O. Box 7
Crater Lake, OR 97604